Executive Summary

Background and Objectives: The discharge of ships' ballast water is probably the greatest single source of new introductions into aquatic habitats (Carlton & Geller 1993; Cohen & Carlton 1995; Cohen 1998). Recent ballast introductions in the Bay/Delta system include the Asian clam, which has transformed upper bay trophic dynamics with possible impacts on endangered and sport fish (Kimmerer *et al.* 1994), and may be acting as a contaminant pathway delivering selenium at toxic concentrations to bottom-feeding birds and fish (Thompson & Luoma 1999); several species of Asian copepods and mysid shrimp, which may also be altering food availability to endangered and sport fish in the upper Bay and Delta (Meng & Orsi 1991; Orsi 1995); and possibly the Chinese mitten crab, which has invaded and interfered with state and federal water diversion facilities, power plants and wastewater treatment plants, may reduce the stability of levees as well as river banks, ditches and berms, and may compete with crayfish that support a commercial fishery in the Delta (Cohen & Carlton 1997). Judging from introductions that have occurred elsewhere, future ballast water introductions in the Bay and Delta could have even more severe impacts on water delivery systems, endangered fish, commercial fisheries and even on human health.

Despite the importance of this invasion vector, the ballast water arriving in the Bay and Delta has never been sampled. We thus have no direct information on the types and numbers of exotic ballast water organisms being introduced into the Bay/Delta ecosystem or on the physical and chemical characteristics of this ballast water, and little information on the sources and volumes of ballast water being discharged. Such information is urgently needed for the development, implementation and monitoring of ballast water treatment and management efforts; for the development of regulatory policy; and for scientific efforts to understand the factors that contribute to the rate and extent of invasion in different ecosystems.

This project will compile and analyze shipping data and sample and analyze ballast water arriving in the Bay/Delta region in order to develop:

- Data on the types and concentrations of organisms arriving from different source regions, which are needed to conduct relative risk assessments and to develop risk assessment-based ballast water management systems.
- Data on the types and concentrations of organisms and on the physical or chemical parameters of exchanged and unexchanged ballast water, which are needed to assess the effectiveness of exchange and to develop and assess methods to monitor exchange.
- Data on the types and sizes of organisms and on the physical or chemical characteristics of ballast water arriving at Bay/Delta ports, which are needed to develop and assess treatment approaches.
- Data on the types organisms and on chemical or microbial contaminants in ballast water that may pose environmental or public health risks, which are needed to determine the urgency and appropriate scope of regulatory action on ballast water.
- Data on the types and concentrations of organisms arriving in ballast water, which are needed to conduct comparative analyses between ecosystems and over time to assess which factors control the rate and extent of invasion.

Methods: This 2-year project will: acquire and analyze data on shipping patterns; sample and analyze the biota and the chemical and physical parameters of ballast water and sediments arriving in the Bay/Delta system; and test this data for correlations over time and between estuaries for correlations between ballast water biota, ballast water source regions, and the establishment of non-indigenous species. Data on ship arrivals (e. g. ship type, size, last port-of-call) from the San Francisco Marine Exchange and other sources will be analyzed for ballast water volumes and sources, and changes and trends over time. Ballast sampling will be conducted by vertical plankton tows or pump sampling, for a range of vessel types, sizes and source regions. Sediments, macrofauna and other seawater system components will be sampled as opportunity permits. Whole water samples will be collected for physical, chemical and microbial analysis.

Biologic samples will be examined initially to determine if the plankton is alive and, if funding for this component is available, subsamples will be taken for culturing larval zooplankton. The remaining sample will be fixed for later sorting, identification to lowest possible taxon and enumeration.

Location: The laboratory and analytical work will be conducted at SFSU's Romberg Tiburon Center in Marin County and the San Francisco Estuary Institute in Contra Costa County, with supplemental laboratory work at CDFG/IEP in San Joaquin County and USGS in San Mateo County. Ships will be sampled at all Bay/Delta commercial ports, which are located in Sacramento, San Joaquin, Solano, Contra Costa, Alameda, San Mateo and San Francisco counties.

Cost: The request to CALFED is $375,905 over 2 years. Cash and in-kind contributions, primarily from the San Francisco Bay RWQCB for water quality analysis, are about $50,0000. An additional $171,000 is requested from National Sea Grant for a separable component involving the culturing and further identification of larval zooplankton.

Applicant Qualifications: Project Leader **Andrew Cohen** has conducted extensive research on nonindigenous species and transport vectors in the Bay/Delta Estuary and other west coast estuaries, including research on the rate of invasions (published in Science) and ballast water in the Estuary. He has organized and led teams of taxonomists and ecologists in Rapid Assessment Surveys for nonindigenous species in the Bay/Delta Estuary and Puget Sound, and was recently awarded a Pew Fellowship in Marine Conservation to investigate biological invasions in tropical marine ecosystems. Project co-leader **Wim Kimmerer** has conducted research on zooplankton ecology and computer modeling on such topics as the influence of predation on community structure, population dynamics of zooplankton and fish, and the interaction of plankton with their physical environment, and has published several papers on the influence of introduced species on the Bay/Delta ecosystem. He is Chair of the Interagency Ecological Program's Estuarine Ecology Team. Project Co-leader **Steven Moore** is an Associate Engineer with the Regional Water Quality Control Board, with experience in wetlands permitting, watershed monitoring and assessment, NPDES permitting and compliance, total maximum daily load (TMDL) development and implementation, and toxic pollutant control. He is currently working on the development of a TMDL for nonindigenous species in the Estuary. Project collaborators identified to date bring additional expertise in ballast water sampling, and zooplankton and protozoan taxonomy.

Local Support/Coordination: Participants in ballast water treatment studies, including the Port of Oakland, San Francisco Oceanside Laboratory and Southeast Wastewater Treatment Plant, Central Contra Costa Sanitary District, Contra Costa Water District, SWRCB and San Francisco Bay RWQCB either have been or will be notified of this study, and will have an opportunity to review the methods and results. All of the ports and many of the terminals in the Bay/Delta region will be contacted for this study, and will similarly have an opportunity to review methods and results. The Center for Marine Conservation and the San Francisco BayKeeper are aware of the proposed project and strongly support it. The Contra Costa County Board of Supervisors and Planning Department, the Delta Protection Commission and the Bay Conservation and Development Commission have been advised of the project. We anticipate that researchers or students from several institutions may become involved in this study in one way or another.

Compatibility with CALFED objectives: An ERP "Stage 1 Expectation" is that "baseline monitoring of the organisms released in ballast water should be immediately initiated so we can assess progress and monitor compliance" (Vol. I, p. 464). Several targets, actions and objectives in the ERP and Strategic Plan call for stopping the discharge of exotic organisms in ballast water into the Estuary, recognizing that the introduction of new species greatly increases the expense and difficulty of restoring the estuary, and that a new invasion can destroy the value of a restoration project (Vol. I, p. 464); and that the elimination of additional species introductions is crucial to the ultimate success of the ERP (Vol. I, p. 462, citing the Strategic Plan).

Project Description

Problem Statement and Objectives

Data on ballast biota arriving in the San Francisco Bay Estuary are needed (1) to assess the risk of introductions, determine treatment standards, design treatment options, and provide baseline data to assess management or treatment efforts; (2) to analyze temporal and spatial patterns of recent ballast introductions; and (3) to conduct critical comparative analyses between estuaries.

1) Recent policy activities suggest that management or treatment of ballast water could soon be implemented in the Bay/Delta system. Baseline data on ballast water biota and ballast water chemistry are urgently needed to assess the ecological, economic and public health risks of ballast discharges, to set standards for treatment, to design treatment or management approaches, and to assess the effectiveness of these approaches in practice.

2) Some researchers have argued that several recent invasions in San Francisco Bay are linked to changes in shipping and in the biota carried in ballast water. Data on shipping patterns and ballast biota are needed to test this.

3) Comparative analyses of invasion vectors and patterns are needed to understand the relative influence of vector factors and ecosystem factors on invasion rate and extent (Cohen & Carlton 1998). These require data on both arriving and established non-indigenous species. A comprehensive study of established non-indigenous species has been published for the Bay/Delta estuary (Cohen & Carlton 1995) and others are in progress (for Chesapeake Bay, Pearl Harbor, Prince William Sound). Arriving ballast water has been studied in the last three of these ecosystems, but not in the Bay/Delta estuary.

This project has six specific research objectives:

- To acquire and analyze data on ship arrivals in San Francisco Bay over the past two decades to determine changes and trends in the sources and in the estimated volumes of ballast water arriving.
- To develop and analyze data on the non-indigenous biota in arriving ballast water for comparative studies with other estuaries.
- To develop data on the non-indigenous biota and chemical contaminants in ballast water discharges to enable assessment of ecological, economic and public health risks.
- To develop data on the types of organisms in ballast water and on the chemical and physical condition of ballast water that are needed to develop effective treatment options.
- To develop baseline data on the biota of ballast water discharges to enable assessments of regulatory approaches that may be taken and of management or treatment methods as they are applied.
- To test for correlations between the timing of changes in ballast water source regions (and the ballast biota associated with those source regions), and the establishment of ballast-associated non-indigenous species in the San Francisco Bay Estuary.

Scope of Work
This project will:

- Sample and analyze the organisms, chemical contaminants and water quality parameters in water and sediments arriving in ships' ballast tanks and seawater systems into the San Francisco Bay ecosystem.
- Acquire and analyze data on shipping patterns.
- Test this data for correlations over time between changes in ballast water source regions (and ballast biota), and the establishment of non-indigenous species in the San Francisco Bay ecosystem.
- Test this data and available data from other estuaries for correlations over estuaries between ballast biota and the establishment of non-indigenous species.

Shipping data: Data on ship arrivals (e. g. ship type, size, last port-of-call) over the last two decades will be acquired from the San Francisco Marine Exchange and augmented with data from other sources for each port in the Bay/Delta system. Previously described methods will be used to estimate ballast water volumes (Carlton et al. 1995; Cohen 1998), and prior port-of-call data will be obtained as needed from other Pacific Coast data sources to determine probable ballast sources. These data will be analyzed for changes and trends in ballast sources and volumes over time.

Ballast water sampling and analysis: Sampling will be initially arranged through port companies or shipping agents. Ships' officers will be interviewed regarding the history of the ballast water carried and the ship's ballast discharge plans. Where tank access and architecture allows, vertical plankton tows (3-5 replicates, 80 µm mesh net) will be used to obtain vertically integrated samples. Pump sampling will be used to capture different tank depths, or where access is limited to sounding pipes. Details of sampling methods have been previously described (Dodgshun & Handley 1997, Sutton et al. 1998). Vessels will be selected for a range of source regions (both Pacific Coast and overseas), vessel types and sizes that are representative of the set of ships arriving in the port system. Both exchanged and unexchanged tanks will be sampled. Sediments and macrofauna (fish and larger invertebrates sampled with dip nets), and seawater system components other than ballast tanks, will be sampled as opportunity permits. Whole water samples will be collected for physical, chemical and microbial analysis.

Biologic samples will be cooled and aerated for transport to the laboratory, where they will be examined initially to determine if the plankton is alive. If funding for this component is available, subsamples will be taken for culturing larval zooplankton to later larval or adult stages, so they can be more readily or more precisely be identified (funding for larval culturing, a separable component of this project, is being sought elsewhere; see **Cost-Sharing**, below). The remaining sample will be fixed in buffered formalin for standard sorting, identification to lowest possible taxon, and enumeration; with consultation or voucher confirmation by taxonomic specialists as needed. Whole water samples will be analyzed for physical and chemical parameters relevant to ecological analysis and to the evaluation of ballast water treatment options, and for chemical contaminants and coliforms by a laboratory under contract to the Regional Water Quality Control Board (with funding provided by the Board).

Data analysis: With data from this study and updated data on established non-indigenous species from Cohen & Carlton (1995), standard statistical methods will be used to test for correlations between changes over time in source regions, source port type (e. g. estuarine or deepwater) or ballast volumes and the establishment of ballast-associated non-indigenous species; for differences in non-indigenous species abundance and diversity between exchanged and unexchanged ballast tanks; and with data from other estuaries, for correlations between the abundance or diversity of

non-indigenous species in arriving ballast water and the number of non-indigenous species established.

Schedule and Deliverables
This is a 2-year project, with sampling conducted over 18-20 months of the project period.

- A one-year progress report will include the analysis of historic shipping data; a description of the progress to date on the ballast water sampling and analysis, with any problems encountered; and information on the diversity and abundance of the organisms in and the chemical and physical characteristics of the ballast water as determined to that date.

- A meeting/workshop will be held, including all project principals and collaborators and affected regulators, resource managers, stakeholders. etc., to review the progress report and consider whether modifications should be made in the sampling program during the remainder of the project period and whether funds should be sought to continue ballast water sampling beyond the initial project period.

- The final project report will contain the full set of analyses and data from the project.

Location/Boundaries
The primary laboratory and analytical work will be conducted at the San Francisco State University/Romberg Tiburon Center in Marin County and the San Francisco Estuary Institute in Contra Costa County, with supplemental laboratory work at the California Department of Fish & Game/Interagency Ecological Program in San Joaquin County and the U. S. Geological Survey in San Mateo County. Ships will be sampled at all commercial ports in the Bay/Delta region, which are located in Sacramento, San Joaquin, Solano, Contra Costa, Alameda, San Mateo and San Francisco counties (see enclosed maps).

Key to Maps

Offices & Laboratories (squares)

Primary:

A San Francisco Estuary Institute, Contra Costa County
B San Francisco State University/Romberg Tiburon Center, Marin County

Supplemental:

C U. S. Geological Survey, San Mateo County
D California Department of Fish & Game/Interagency Ecological Program, San Joaquin County

Potential sampling locations at ports and terminals (circles)

1 Port of San Francisco, San Francisco County
2 Port of Redwood City, San Mateo County
3 Port of Oakland, Port of Alameda (Encinal), Alameda County
4 Port of Richmond, Chevron Longwharf, Contra Costa County
5 San Pablo Bay terminals, Contra Costa County
6 Port of Benicia, Solano County
7 Martinez terminals, Contra Costa County
8 Pittsburg terminals, Contra Costa County
9 Antioch terminals, Contra Costa County
10 Port of Stockton, San Joaquin County
11 Port of Sacramento, Sacramento County

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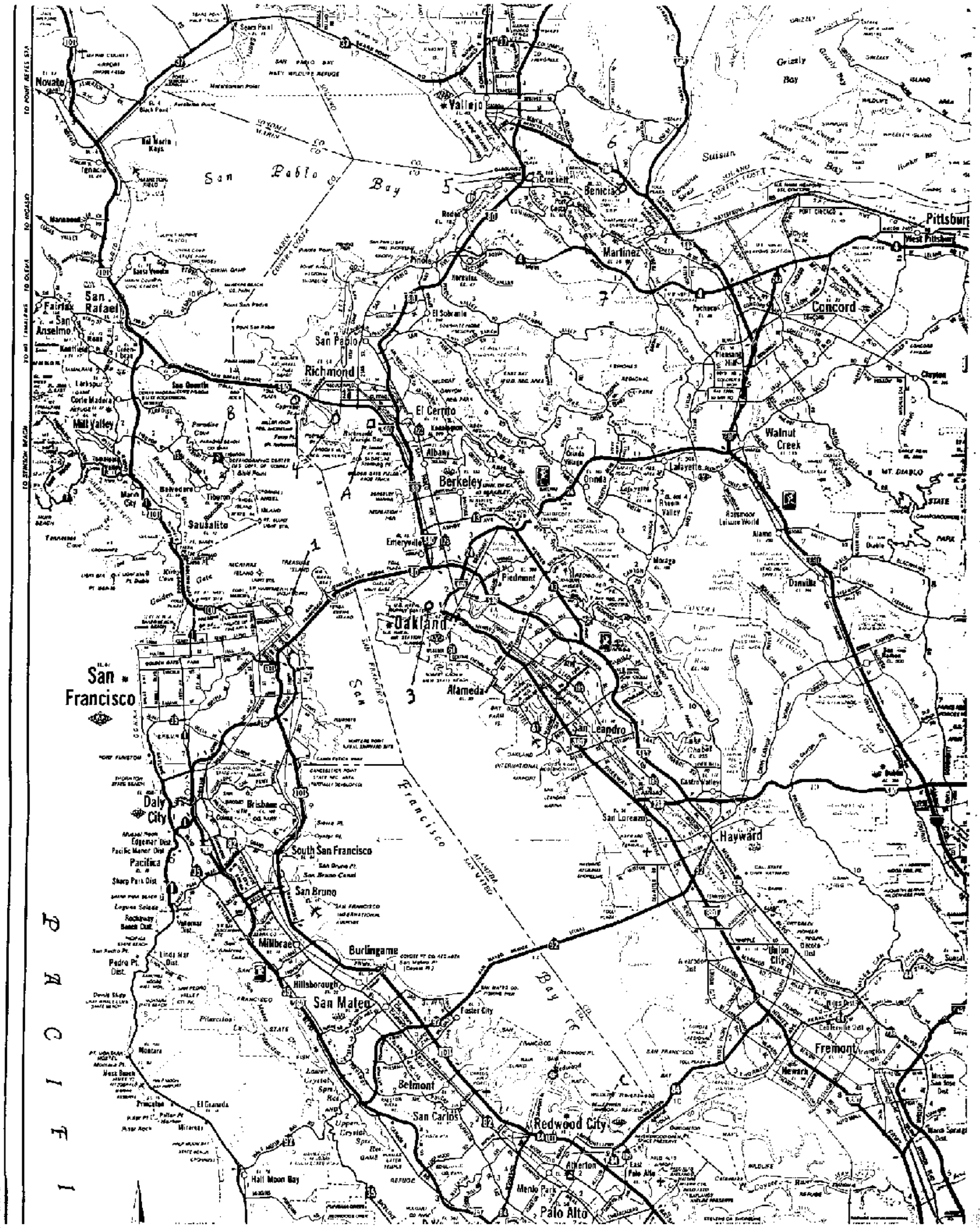

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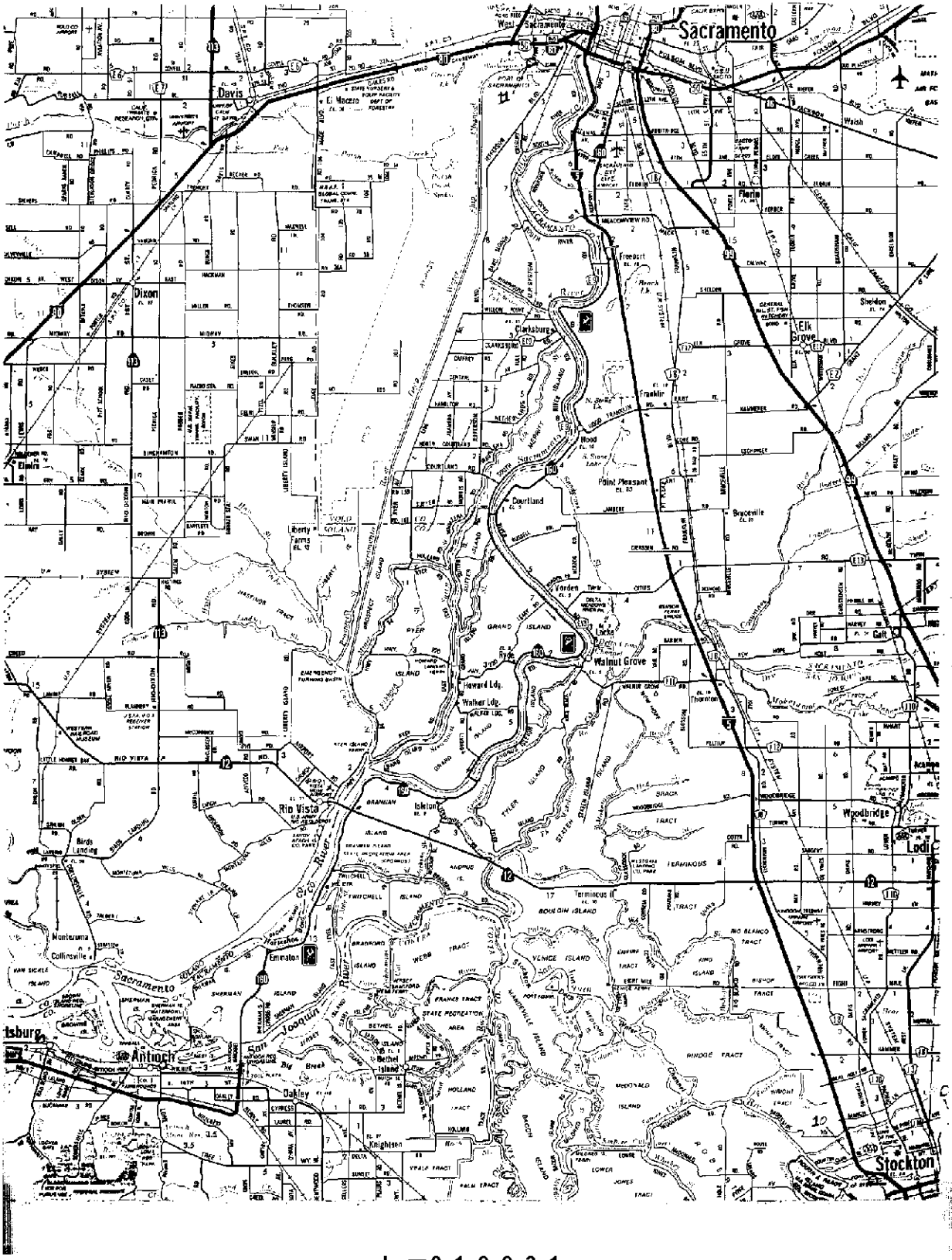

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Project Benefits

Ecological/Biological Objectives

The primary project objective is to develop data that is needed for (1) assessments of the risks and potential impacts of biological invasions from ballast water discharges in the Bay/Delta estuary; (2) the development or assessment of alternatives for ballast water management, including ballast exchange and treatment; and (3) analyzing the factors that control the rate and extent of invasion in estuarine ecosystems. Specifically, this project will compile and analyze shipping data and sample and analyze the biological, chemical and physical components of ballast water arriving in the Bay/Delta region, in order to support the following needs:

- Data on the types and concentrations of organisms arriving from port regions in different parts of the world are needed to conduct relative risk assessments and to develop a risk assessment-based ballast water management system. Although the viability of such management systems have been questioned by some researchers, this appears to be the approach generally preferred by the shipping industry.
- Data on the types and concentrations of organisms in exchanged and unexchanged ballast water, and on differences in physical or chemical parameters, are needed to assess the effectiveness of at-sea ballast water exchange and to develop and assess methods for monitoring exchanges. Ballast exchange has been proposed as a mitigation measure by the Port of Oakland, and may soon be required by agency action or new state law (AB 703).
- Data on the types and sizes of organisms carried in the ballast water arriving at Bay/Delta ports, and on physical and chemical parameters that might affect treatment processes (such as turbidity, dissolved organic carbon, pH, iron content, alkalinity, etc.) are needed to develop and assess effective treatment options for ballast water. Ballast water treatment appears to be the approach preferred by environmental groups.
- Data on the types and concentrations of organisms arriving in ballast water, and on chemical or microbial contaminants that may pose environmental or public health risks (such as the presence of organic or inorganic pollutants, toxin-producing dinoflagellates, fecal coliforms, anti-biotic resistant bacteria, cholera bacteria, etc.) are needed to assess the urgency and appropriate scope of regulatory activities regarding ballast water discharges.
- Data on the types and concentrations of organisms arriving in ballast water are needed to conduct analyses of invasion vectors and the rate and extent of invasions across ecosystems and over time, to determine whether invasions are primarily driven by conditions in the invaded ecosystem (so that new invasions may be prevented by altering those conditions, such as controlling a source of disturbance), or are primarily driven by the nature and scale of the transport vectors, so that preventing invasions means controlling the vectors.

Organisms introduced by ballast water may affect virtually any aquatic habitat and all trophic levels in the Bay or Delta, and there are numerous examples of ballast introductions having severe impacts in fresh, brackish and saltwater habitats, and in open water, subtidal and intertidal habitats.

Linkages

Links to other projects: This project follows directly from earlier studies funded by USFWS and CALFED, and will provide useful information for ballast water treatment studies and ecosystem analyses for which funding is expected or being sought. The Bay/Delta invasions study conducted pursuant to the National Aquatic Nuisance Species Protection and Control Act concluded that "urgently required is a San Francisco Bay Shipping Study...[including] all Bay and Delta ports. A biological and ecological study of the nature of ballast water biota arriving in the Bay/Delta system is urgently required." The CALFED-funded ballast water study (Cohen 1998) likewise found that "the ballast water arriving in the Estuary should be sampled and analyzed to characterize the diversity and abundance of exotic organisms it carries, its water quality parameters, the degree to which it is contaminated by sewage or other pollutants, and any potential public health risks," and that "data on recent shipping activity in the Estuary should be compiled and analyzed."

Project data on the biota and the chemical and physical parameters of ballast water arriving in the Estuary will be useful for three pending studies on ballast water treatment: USFWS has promised initial funding for one study organized by the San Francisco Estuary Institute (SFEI) to assess the feasibility and develop pilot projects for on-shore ballast water treatment; SFEI and the San Francisco Water Quality Bureau are seeking funding for a second study to investigate the potential for treatment at existing municipal wastewater treatment plants; and a third study comparing on-shore treatment and ballast exchange has been proposed by the California Association of Port Authorities. Project data will also be useful for a proposed study by the Smithsonian Environmental Research Center, SFEI and the Centre for Research on Introduced Marine Pests in Australia, comparing non-indigenous biota and transport vectors in Chesapeake Bay, San Francisco Bay and two estuaries in eastern and western Australia; and for other comparative studies that may be conducted in the future.

Links to CALFED's overall objectives: CALFED's Strategic Plan states that "in order to minimize the risk of potentially massive ecological and biological disruptions associated with non-native species disruptions that could threaten to negate the benefits of restoration efforts, it is important to initiate an early program that prevents or significantly reduces additional introductions of non-native species." Strategic objectives include preventing the "establishment of additional non-native species" and rehabilitating "the capacity of the Bay-Delta system to support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities, in ways that favor native members of those communities." The vision for non-native aquatic species is to "reduce their adverse effects on the foodweb and on native species resulting from competition for food and habitat and direct predation," including impacts on such important native and nonnative species as delta smelt, longfin smelt and striped bass whose recovery is among CALFED's objectives.

Links to the ERP: This project directly relates to the following ERP expectations, targets, actions and objectives:

- "Baseline monitoring of the organisms released in ballast water should be immediately initiated so we can assess progress and monitor compliance" (Vol. I, p. 464)
- "Eliminate further introductions of new species in ballast water of ships" (Vol. I, p. 420; Vol. II, pp. 112, 151). "Eliminate the dumping of all organism-contaminated ballast water and ballast sediment into the estuary" (Vol. I, p. 464). "Develop and implement a ballast water management program to halt the introduction of introduced species into the estuary" (Vol. II, p. 151).
- "Help fund ballast water treatment techniques that could eliminate non-native species before ballast water is released" (Vol. II, pp. 112, 151).
- "Prevent the introduction of the zebra mussel into California" (Vol. I, p. 420).
- "Halt the introduction of invasive aquatic...plants into central California" (Vol. I, pp. 420, 456).
- "Reduce the concentrations and loading of contaminants in all aquatic environments in the Bay-Delta watershed" (Vol. I, p. 421).

The ERP notes that the introduction of new species greatly increases the expense and difficulty of restoring the estuary, and that a new invasion can destroy the value of a restoration project (Vol. I, p. 464); and that the elimination of additional species introductions is crucial to the ultimate success of the ERP (Vol. I, p. 462, citing the Strategic Plan).

Links to agency mandates: Several state and federal agencies have initiated efforts to manage the release of exotic species in ballast water or may have responsibility for doing so under various statutes or administrative actions, and this study will provide information that is useful and perhaps critical for those efforts. Responsible or potentially responsible agencies include:

- the RWQCBs—the San Francisco Bay RWQCB has initiated the setting of a Total Maximum Daily Loading (TMDL) for exotic species discharged in ballast water, with regulations to follow;

- SWRCB—which has proposed including ballast water regulations in the California Ocean Plan; both the SWRCB and the RWQCBs may have direct responsibility for ballast water discharges under California's Porter-Cologne Water Quality Act;
- USFWS—which may have responsibilities under the federal Endangered Species Act or the National Invasive Species Act (NISA);
- US EPA—which may be required to regulate ballast water under the Clean Water Act;
- US Coast Guard—under NISA.

Other laws which may establish agency responsibilities for managing ballast discharges include the federal lace Act (affecting USFWS) and various provisions of the California Fish and Game Code (affecting CDFG). The recent Presidential Executive Order #13112 directs federal agencies to take all necessary steps to prevent the introduction of invasive species, which may reasonably include regulating ballast discharges.

System-Wide Ecosystem Benefits

Nonindigenous organisms introduced into and established in one part of the Bay/Delta watershed may readily spread to other parts. For example the Asian clam *Potamocorbula amurensis*, apparently first established in the Suisun Bay, quickly spread throughout the lower bay, and the Chinese mitten crab *Eriocheir sinensis*, first reported from the South Bay in 1992, has spread throughout the Bay and Delta and well up into the tributary waterways of the Central Valley and the Bay region, and is apparently still spreading. Apparently all parts of the watershed may be at risk from invasions by nonindigenous species established by ballast discharges anywhere in the Bay/Delta system. So, by contributing to efforts to manage ballast discharges in the Bay/Delta system this project may provide benefits throughout the watershed.

Controlling the introduction of nonindigenous species in ballast discharges may link with other ecosystem elements and objectives. For example, introduced species may compete with native or other important sport or food species for food, may displace or alter the available food resources of important species and disrupt trophic pathways, may make some contaminants more bioavailable. Abundant fouling or clogging organisms—such as zebra mussels, the freshwater Asian clam *Corbicula fluminea*, mitten crabs or aquatic plants—may impair the functioning of fish protective devices such as fish screens in the Delta and tributary rivers, may obstruct fish salvage operations, or may interfere with the safe passage of fish up fish ladders.

Compatibility with Non-Ecosystem Objectives

As noted in the ERP, aquatic invasions have harmed public health, decimated fisheries and impeded or blocked water supplies (Vol. I, p. 464). The introduction of burrowing organisms such as mitten crabs may accelerate bank erosion and pose a threat to Delta levee integrity. By supporting efforts to control the release of exotic species in ballast discharges, this project could reduce risks to water supply reliability, levee integrity, and water quality.

Project data will contribute to understanding the factors that affect the rate and extent of invasions in estuaries, which should result in more efficient control strategies that target the most important factors. This will benefit federal and state agencies charged with controlling biological invasions; will benefit stakeholders at risk of impacts from invasions (such as the aquaculture and commercial fishing industries, recreational boaters and fishers, water agencies and power plants); and might also benefit industries that could be subjected to regulations to prevent invasions, by focusing regulations on the most critical invasion factors.

Project data will be used to assess the ecological, economic and public health risks of ballast discharges; to develop treatment options; and to assess the effectiveness of regulatory approaches and treatment methods. These data may be used by regulatory agencies (including SWRCB, San Francisco Bay and Central Valley RWQCBs, US EPA, USFWS, NMFS, CDFG, etc.); stakeholders (shipping companies, ports, oil terminals, US ACE, civic and environmental groups); and researchers investigating biological invasions in this ecosystem and elsewhere.

Feasibility and Timing

Alternatives Considered

Do not sample ballast water: A general description of the expected types of biota to be found in ballast water could be derived from ballast water studies conducted elsewhere, and much of the available information has been summarized by Cohen (1998). However this approach would not provide the specific information needed to conduct relative risk assessments; to assess the effectiveness of at-sea ballast exchange as conducted by ships entering Bay/Delta waters; or to conduct analyses of invasion vectors and the rate and extent of invasions across ecosystems and over time. There is little available information even in a general sense on levels of microbial or chemical contamination in ballast water, and on the physical and chemical parameters that may affect treatment options; and specific information on these questions for the Bay/Delta region, as well as specific information on the arriving biota, would be lacking.

Longer or shorter duration of sampling program: While a shorter, and therefore somewhat cheaper, sampling project could be conducted that would produce useful information on the biological, physical and chemical characteristics of ballast water in the Bay/Delta region, given the time required to set up such a program and get it operating smoothly (both technically and in terms of organization and co-ordination), we judge that a project of at least 2 years' duration with sampling conducted over 18-20 months of that period would make for an efficient use of resources. A longer project could have substantial added value, however we think that the merits of a longer sampling program could be assessed after this project was underway, and if thought to be worthwhile, additional funding could then be sought. We have included such a review in the project plan (see **Schedule and Deliverables**, above).

Delete components: The acquisition and analysis of shipping data could be deleted or pursued as a separate project; but this analysis will produce information on the sources and volumes of ballast water and on trends in these over time that would add substantial value to the data gathered from ballast water sampling at relatively modest additional cost.

Add components: We are simultaneously seeking funding from the National Sea Grant College Program to culture subsamples of larval zooplankton to later larval or adult stages for identification (preproposal for $171,000, submitted on 4/5/99). Many of the organisms in ballast water are present only in larval form (the adults being non-planktonic), and without such culturing these organisms would only be identified to higher taxonomic levels (family or higher), providing limited information on biotic composition. If Sea Grant decides not to award funding, a larval culturing component could be usefully included with the CALFED-funded work. Other aspects of taxonomic analysis (e. g. identification of phytoplankton, and of dinoflagellate cysts and algal spores, including toxin-producing species; detailed analysis of bacteria in ballast water and sediments, including assessment of the presence of human pathogens or anti-biotic resistant strains) could also be included, and we might seek funding to add such studies to the ballast water sampling program from other sources or from future CALFED solicitations. During the sampling program, it may also be possible to arrange with certain ships for observational or experimental studies on the biota or ecology of ballast water over the course of a voyage.

Compliance Documents

No compliance documents will be needed to conduct this project.

Monitoring/Data Collection

Objectives

This project has six research objectives:

- To acquire and analyze data on ship arrivals in the Bay/Delta system over the past two decades to determine changes and trends in the sources and in the estimated volumes of ballast water arriving.
- To develop and analyze data on the non-indigenous biota in arriving ballast water for comparative studies with other estuaries.
- To develop data on the non-indigenous biota and chemical contaminants in ballast water discharges to enable assessment of ecological, economic and public health risks.
- To develop data on the types of organisms in ballast water and on the chemical and physical condition of ballast water that are needed to develop effective treatment options.
- To develop baseline data on the biota of ballast water discharges to enable assessments of regulatory approaches that may be taken and of management or treatment methods as they are applied.
- To test for correlations between the timing of changes in ballast water source regions (and the ballast biota associated with those source regions), and the establishment of ballast-associated nonindigenous species in the Bay/Delta estuary.

Collection Approach

Sampling will be conducted by a 2-person team, typically an Environmental Analyst and an Intern. Samples will generally be taken by vertical plankton tows (3-5 replicates, 80 µm mesh) or pump sampling, depending on the type of ballast tank and available access. Methods for ballast water sampling have been described by Dodgshun and Handley (1997) and Sutton *et al.* (1998). Samples will be taken from as many ballast tanks as can be accessed on each ship. Whole water samples will be collected for physical, chemical and microbial analysis. Depending on the availability of ships and the number of samples taken per ship, we expect to sample an average of 1-2 ships per week. Ships calling at ports and terminals throughout the estuary will be sampled (see maps enclosed). Vessels to be sampled will be selected to cover a representative range of source regions, vessel types and sizes. Sediments and macrofauna will be sampled when possible. Seawater system components other than ballast tanks will be sampled as opportunity permits.

Data Evaluation

Biologic samples will be cooled and aerated for transport to the laboratory, initially examined for live plankton and, if funding for larval culturing is available, subsamples taken for this purpose. The remaining sample will be fixed in buffered formalin for sorting, identification to lowest possible taxon, and enumeration. Taxonomic specialists will be consulted as needed. Water samples will be analyzed for a range of physical, chemical and microbial parameters (see Table 2 for examples) using standard protocols. Methods and approaches will be reviewed as appropriate by the ballast sampling technical consultant; a ballast sampling advisory group consisting of researchers who have conducted ballast samplings and shipping studies and the taxonomists and technicians who may be examining the samples; the ballast water treatment research teams for the studies noted in "Linkages to other project" under **Project Benefits**; or by the water quality regulatory agencies. Results will be subject to external peer review. A progress report will be produced midway through the project, after which a meeting will be held, including project principals, collaborators and affected regulators, resource managers, stakeholders, etc., to review the project and consider modifications to the project and the value of continuing the sampling program beyond the project period. A final report will be produced at the conclusion of the project

Table 2. Monitoring Data and Collection Information

Question to be addressed	Monitoring parameters/Data collection	Protocol references	Data evaluation
Sources and volumes of ballast water arriving in Bay/Delta ports	Data acquired and analyzed from: San Francisco Marine Exchange, National Biological Invasions Shipping Study, US Census Bureau Monthly Vessel Entrance data (TM-385), National Ballast Water Clearinghouse (SERC), and survey of ships boarded for sampling.	Carlton *et al.* 1995	Survey reviewed by technical consultant and advisory group. External peer review of results.
General ballast water sampling protocols	Vertical plankton tows (80 µm mesh) and/or filtered pump samples for zooplankton; supplemental sampling of tanks sediments, macrofauna, other seawater system components as possible. Whole water samples for physical, chemical and microbial analysis.	Dodgshun & Handley 1997; Sutton *et al.* 1998	Methods reviewed by technical consultant and advisory group.
Mature zooplankton	Initially examined for live plankton; fixed, sorted, identified to lowest possible taxon, and enumerated.		Confirmation of identifications by taxonomic specialists as needed. External peer review of results.
Larval zooplankton	Initially examined for live plankton; fixed, sorted, identified to lowest possible taxon, and enumerated. Subsamples cultured by standard techniques to adult or latest possible larval stage, then fixed, sorted and identified to lowest possible taxon.	Strathmann 1997	Confirmation of identifications by taxonomic specialists as needed. External peer review of results.

I-019937

Table 2 continued. Monitoring Data and Collection Information

Question to be addressed	Monitoring parameters/Data collection	Protocol references	Data evaluation
Physical and chemical factors of environmental health or public health concern	Examples of parameters that may be measured include: turbidity, standard minerals analysis (alkalinity, ammonia-nitrogen, bicarbonate, boron, calcium, chloride, sp. conductance, fluoride, iron, magnesium, nitrate-nitrogen, pH, potassium, sodium, sodium hydroxide, sulfate, total anions, total cations, total dissolved solids, total hardness (as CaCO3) and total phosphate-P), total suspended solids, settleable solids, dissolved oxygen, chemical oxygen demand, biochemical oxygen demand (five-day), 10 priority pollutant metals (As, Cd, Cu, Cr, Pb, Hg, Ni, Se, Ag, Zn) (GFAA method), phenols (EPA 604), organochlorines pesticides and PCBs (8080), polynuclear aromatic hydrocarbons (8100), chlorinated hydrocarbons (8120), organophosphate pesticides (8140), chlorinated herbicides (8150), semivolatile organics (8270), dithiocarbamate pesticides (630), carbamate and urea pesticides (630), total coliform (25 tube), fecal coliform (25 tube), fecal streptococcus, *Giardia*, microbial DNA analysis.	for organic compounds: EPA method 604, 630, 8080, 8100, 8120, 8140, 8150, 8270	Set of parameters to be measured reviewed by water quality regulatory agencies. External peer review of results.
Physical and chemical factors that may affect treatment approaches	Examples of parameters that may be measured include: temperature, pH, turbidity, UV transmittance, total suspended solids, particle size distribution, dissolved organic carbon, Fe, Mn, alkalinity, bromide, ammonia, nitrite, target organism sizes, target organism concentrations.	Oemke & van Leeuwen 1998	Set of parameters to be measured reviewed by ballast water treatment research teams. External peer review of results.

Local Involvement

The Contra Costa County Board of Supervisors, the Contra Costa County Planning Department, the Delta Protection Commission and the Bay Conservation and Development Commision have been advised of the proposed project.

The Center for Marine Conservation and the San Francisco BayKeeper are aware of the proposed project and strongly support it.

Staff at the Port of Oakland and the Port of Sacramento have been advised of the proposed project. As noted in "Linkages to other project" under **Project Benefits**, project data on ballast water biota and physical and chemical characteristics may be useful for an investigation of ballast water treatment proposed by the California Association of Port Authorities, which the Port of Oakland is helping to develop. All of the ports and many of the terminals in the Bay/Delta region will be contacted for this study, and will have the opportunity to review the methods and results.

Participants in other ballast water treatment studies in the Bay/Delta Region, including staff at the San Francisco Oceanside Laboratory, San Francisco Southeast Wastewater Treatment Plant, Central Contra Costa Sanitary District, Contra Costa Water District, Port of Oakland, SWRCB and San Francisco Bay RWQCB either have been or will be notified of this study, and will similarly have an opportunity to review methods and results.

We anticipate that number of researchers at different institutions or agencies in the region will be involved in this study, or in supplemental studies that build upon it, in one way or another. Those involved thus far in the course of preparing the proposal include researchers from SFEI, SFSU/Romberg Tiburon Center, CDFG/IEP, USGS and RWQCB.

San Francisco Estuary Institute

180 Richmond Field Station
1325 South 46th Street
Richmond, California 94804
Office (510) 231-9539
Fax (510) 231-9414

April 15, 1999

Supervisor Joe Canciamilla, Chair
County of Contra Costa
Board of Supervisors
651 Pine Street
Martinez, CA 94553

Dear Supervisor Canciamilla:

Per instructions stated in the CALFED Bay-Delta Program, February 1999 Proposal Solicitation Package, this letter serves to notify you of our intent to submit the project proposal entitled "Determining the Biological, Physical and Chemical Characteristics of Ballast Water Arriving in the San Francisco Bay/Delta Estuary".

If you have any questions, please contact me.

Very truly yours,

Margaret R. Johnston
Executive Director

San Francisco Estuary Institute

180 Richmond Field Station
1325 South 46th Street
Richmond, California 94804
Office (510) 231-9539
Fax (510) 231-9414

April 15, 1999

Dennis M. Barry, AICP, Director
County of Contra Costa
Community Development Department
651 Pine Street
North Wing - 4th Floor
Martinez, CA 94553

Dear Mr. Barry:

Per instructions stated in the CALFED Bay-Delta Program, February 1999 Proposal Solicitation Package, this letter serves to notify you of our intent to submit the project proposal entitled "Determining the Biological, Physical and Chemical Characteristics of Ballast Water Arriving in the San Francisco Bay/Delta Estuary".

If you have any questions, please contact me.

Very truly yours,

Margaret R. Johnston
Executive Director

San Francisco Estuary Institute

180 Richmond Field Station
1325 South 46th Street
Richmond, California 94804
Office (510) 231-9539
Fax (510) 231-9414

April 15, 1999

Margit Aramburu, Director
Delta Protection Commission
14215 River Road
P. O. Box 530
Walnut Grove, CA 95690

Dear Ms. Aramburu:

Per instructions stated in the CALFED Bay-Delta Program, February 1999 Proposal Solicitation Package, this letter serves to notify you of our intent to submit the project proposal entitled "Determining the Biological, Physical and Chemical Characteristics of Ballast Water Arriving in the San Francisco Bay/Delta Estuary".

If you have any questions, please contact me.

Very truly yours,

Margaret R. Johnston
Executive Director

San Francisco Estuary Institute

180 Richmond Field Station
1325 South 46th Street
Richmond, California 94804
Office (510) 231-9539
Fax (510) 231-9414

April 15, 1999

Robert Tufts, Chair
San Francisco Bay Conservation
and Development Commission
30 Van Ness Avenue, Room 2011
San Francisco, CA 94102

Dear Mr. Tufts:

Per instructions stated in the CALFED Bay-Delta Program, February 1999 Proposal Solicitation Package, this letter serves to notify you of our intent to submit the project proposal entitled "Determining the Biological, Physical and Chemical Characteristics of Ballast Water Arriving in the San Francisco Bay/Delta Estuary".

If you have any questions, please contact me.

Very truly yours,

Margaret R. Johnson
Executive Director

Cost

Budget Explanation

This discussion refers to budget tables 3 and 4. This is a 2-year project. The rates for most labor, services and supplies are calculated at 5% greater in the second year. Funding for task 4, the culturing and identification of zooplankton larvae and associated costs for report preparation and project management, are being sought from the National Sea Grant College Program/California Sea Grant (see **Cost-Sharing**, below). Most of the costs for task 5, the analysis of physical and chemical parameters and standard microbial analysis, will be paid for by the San Francisco Bay Regional Water Quality Control Board. M. Wonham's salary, benefits and overhead will be paid by a University of Washington fellowship (task 2).

Salary & Benefits: Benefits are calculated at 18.95% of salary.

Service Contracts: Service contracts include payment for Wim Kimmerer through SFSU, plus payment for additional assistance from other taxonomists ($10,000 in the first year, half that in the second year).

Material and Acquisition Costs: We listed equipment purchases in this category. These include plankton nets, pumps, power sources and electrical converters, sampling bottles and other sampling equipment for ballast water sampling (task 2); microscopy equipment and other laboratory equipment for zooplankton identification (task 3); and office furniture and computer equipment.

Miscellaneous and Other Direct Costs: These include $6500 for the purchase of historic shipping data from the San Francisco Marine Exchange or other sources for task 1; sampling supplies (bottles, fixative, etc.) @≈$2500/yr for task 2; subscription to the Marine Exchange's ship reporting service @≈$500/yr for task 2; local travel @≈$2500/yr for task 2; travel costs to the Bay Area for M. Wonham @$2000 in the first year for task 2; travel to present papers at scientific meetings for project participants @≈$3000/yr for various tasks; laboratory supplies (glassware, reagents, dissecting tools, etc.) @≈2500/yr for task 3; costs for water quality analysis @≈$20,000/yr for task 5 will be paid by the RWQCB and do not appear in the budget tables; miscellaneous costs of ≈$500 for task 2 in the first year include purchase of reports, tools, etc.; miscellaneous costs of ≈$2000 for task 3 over two years include packing & shipping costs, purchase of reports, etc.; miscellaneous costs of ≈$3000 for task 6 over two years include printing costs, purchase of reports, software etc.

Overhead and Indirect Costs: Overhead is calculated at 37.08% of salary and benefits plus 7.0% of service contracts. Overhead rates were calculated by standard methods for federal contracts. State overhead rates are 53.36% on salary and benefits plus 7.0% on service contracts.

Schedule

The acquisition and analysis of historic shipping data will occur during the first two quarters of the first year. Work on the progress report will occur in the fourth quarter of the first year, and on the final report in the last half of the second year. The other tasks will be pursued throughout the project period, with equipment acquisition occurring in the first quarter of the first year. Payments could be tied to the completion of the progress report and the final report.

Table 3. Total Budget (CALFED funds only)

Task	Direct Labor Hours	Direct Salary & Benefits	Service Contracts	Material & Acquisition Costs	Misc. & Other Direct Costs	Overhead & Indirect Costs	Total Costs
1. Acquire & analyze shipping data	187	7,930	0	0	6,500	2,940	17,370
2. Sample ballast water	2,116	59,475	1,864	10,000	15,825	22,184	109,348
3. Identify uncultured zooplankton	3,702	96,895	52,530	15,000	11,250	39,606	215,280
4. Culture & identify larvae	0	0	0	0	0	0	0
5. Chemical/physical analysis	31	1,487	0	0	0	551	2,038
6. Report preparation	311	10,656	5,592	0	3,125	4,343	23,716
7. Project management	93	5,948	0	0	0	2,205	8,153
Total	6,440	182,390	59,986	25,000	36,700	71,829	375,905

Table 4. Quarterly Budget (CALFED funds only)

Task	Oct-Dec 99	Jan-Mar 00	Apr-Jun 00	Jul-Sep 00	Oct-Dec 00
1. Acquire & analyze shipping data	11,935	5,435	0	0	0
2. Sample ballast water	22,940	12,940	12,940	12,940	11,897
3. Identify uncultured zooplankton	40,807	25,807	25,807	25,807	24,263
4. Culture & identify larvae	0	0	0	0	0
5. Chemical/physical analysis	510	510	510	510	0
6. Report preparation	0	0	0	4,533	0
7. Project management	1,019	1,019	1,019	1,019	1,019
Total	77,210	45,710	40,275	44,808	37,180

Table 4 continued. Quarterly Budget (CALFED funds only)

Task	Jan-Mar 01	Apr-Jun 01	Jul-Sep 01	Total Budget
1. Acquire & analyze shipping data	0	0	0	17,370
2. Sample ballast water	11,897	11,897	11,897	109,348
3. Identify uncultured zooplankton	24,263	24,263	24,263	215,280
4. Culture & identify larvae	0	0	0	0
5. Chemical/physical analysis	0	0	0	2,038
6. Report preparation	0	4,796	14,387	23,716
7. Project management	1,019	1,019	1,019	8,153
Total	37,180	41,976	51,567	375,905

Cost Sharing

The San Francisco Bay Regional Water Quality Control Board has agreed to pay for the laboratory costs for water quality analysis, including analysis of physical and chemical parameters and standard microbial analysis. The laboratory work would be conducted by subcontractors to the Regional Board and paid by the Regional Board. These costs are estimated at about $20,000 per year. Steve Moore would manage this part of the project, and his time for this and for other involvement in the project is estimated at about $7,300.

Payment for Marjorie Wonham's time, estimated at $3,000, will be covered by a University of Washington graduate student fellowship. Payment for Mary McGann's time, estimated at $2,000, will be covered by her salary from the U. S. Geological Survey. We anticipate that there may be other collaborators assisting with taxonomic work or other aspects of this research, contributing moderate amounts of time that would be covered by their home institutions. We also anticipate the possibility that graduate or undergraduate research projects may provide other in-kind contributions to this project.

A separable component of this project, the culturing of larval zooplankton to later larval or adult stages and the identification of those stages, has recently been submitted for funding as a preproposal through the California Sea Grant College System to the National Sea Grant Competition for funding for Aquatic Nuisance Species Research and Outreach. The portion of the project being submitted to CALFED for funding can be completed without the larval culturing component, and so is not dependent on SeaGrant awarding funding. However, the reverse is not true: the larval culturing component which we are seeking to fund through Sea Grant could not be done without the basic ballast water sampling program that we are seeking to fund through CALFED and others. Full proposals are due at Sea Grant by May 27, and Sea Grant will provide a response to the preproposal sometime before then; funds are expected to be awarded by around October 1, 1999.

Sea Grant requires a 50% match in non-federal funds for its grants. The request to Sea Grant is for $171,000 over two years. In order to meet the required match along with the other contributions, about 10% of the CALFED would need to be non-federal funding.

We anticipate that we will be developing and seeking funding for other add-on projects to augment the basic ballast water sampling program as opportunity and interest arises. These may, for example, include assessment and identification of phytoplankton, bacteria or viruses; experiments regarding the viability of ballast water organisms if discharged into Bay/Delta waters; or focused investigations of ballast tank sediments or other components of ships' seawater systems.

I-019946

Applicant Qualifications

Project Leader Dr. Andrew Cohen is an Environmental Scientist at the San Francisco Estuary Institute, where he directs a research program on biological invasions in marine and freshwater ecosystems. He received his Bachelor's degree in Environmental Sciences and his Ph. D. in Energy and Resources from the University of California, Berkeley. He has conducted extensive research on nonindigenous species in the Bay/Delta Estuary and other west coast estuaries, and on the transport vectors introducing nonindigenous species into aquatic ecosystems.

Dr. Cohen's research activities and interests have included investigations of: the extent and rate of biological invasions in the Bay/Delta Estuary; invasions by the European green crab, the Chinese mitten crab, the Atlantic rough periwinkle, a Japanese foraminifer and other species; invasion vectors including ballast water, the aquarium/pet trade, aquaculture and the marine baitworm trade; ballast water treatment; prioritizing control efforts for nonindigenous marsh plants; the effect of species characteristics on the initial success of invasions; the effect of environmental factors on the potential spread of invasions; and the role of parasites in obstructing or facilitating host invasions.

Between 1993 and 1998 Dr. Cohen organized and led teams of taxonomic specialists and marine ecologists on five Rapid Assessment Surveys for nonindigenous species in the San Francisco Bay/Delta Estuary and in Puget Sound. He serves on the Executive Committee of the Western Regional Panel on Aquatic Nuisance Species. In 1998 he was awarded a Pew Fellowship in Marine Conservation to investigate biological invasions in tropical marine ecosystems.

In addition to overall project management, Dr. Cohen will have primary responsibility for managing the acquisition and analysis of shipping and ballast water discharge data; for setting up and managing the ballast water sampling program; and with Dr. Kimmerer will manage the larval culturing activities and analysis of sampling data.

Representative Publications

Cohen, A.N. 1998. *Ships' Ballast Water and the Introduction of Exotic Organisms into the San Francisco Estuary: Current Status of the Problem and Options for Management.* A report for CALFED, Sacramento CA.

Cohen, A.N., C.E. Mills, H. Berry *et al.* 1998. *Report of the Puget Sound Expedition, September 8-16, 1998; A Rapid Assessment Survey of Nonindigenous Species in the Shallow Waters of Puget Sound.* Dept. of Natural Resources and USFWS, Olympia WA.

Cohen, A.N. & J.T. Carlton. 1998. Accelerating invasion rate in a highly invaded estuary. *Science* 279: 555-558.

Cohen, A.N. & J.T. Carlton. 1997. Transoceanic transport mechanisms: the introduction of the Chinese mitten crab *Eriocheir sinensis* to California. *Pacific Science* 51(1): 1-11.

Cohen, A.N. & J.T. Carlton. 1995. *Nonindigenous Species in a US Estuary: A Case Study of the Biological Invasions of the San Francisco Bay and Delta.* USFWS, Washington DC.

Project co-Leader Dr. Wim Kimmerer is a Senior Research Scientist at the Romberg Tiburon Center. He received his Bachelor's degree in chemistry from Purdue University and his Ph. D. in biological oceanography from the University of Hawaii in 1980. After a post-doctoral position at the University of Hawaii, he spent 3 years as a Zoology Research Fellow at the University of Melbourne, and subsequently worked as a Senior Scientist at BioSystems Analysis, a scientific consulting firm. He has conducted research in Hawaii, Australia, several tropical Pacific islands, Alaska, and California. At present his work focuses on the San Francisco Bay/Delta ecosystem.

Dr. Kimmerer's diverse research interests include many aspects of biological oceanography and estuarine ecology, with particular emphasis on zooplankton ecology and computer modeling.

Areas of interest include the influence of predation on community structure, population dynamics of zooplankton and fish, the interaction of plankton with their physical environment, and the influences of species introductions and other human activities on coastal marine environments.

Dr. Kimmerer has published several papers on the influence of introduced species on the Bay/Delta ecosystem. He is an expert on the effects of varying freshwater flow on the estuarine ecosystem, and has worked to resolve complex technical issues regarding management of this ecosystem. He led a team of scientists from several agencies and universities in a detailed study of interactions between circulation and movement of organisms in the low-salinity zone of the estuary. He has also conducted analyses and modeling studies of the population dynamics of chinook salmon and striped bass in the Bay and its watershed. He is Chair of the Interagency Ecological Program's Estuarine Ecology Team, and was a member of the CALFED Strategic Planning Core Team.

Dr. Kimmerer will have primary responsibility for managing the identification of zooplankton; and with Dr. Cohen will manage the larval culturing activities and analysis of sampling data.

Representative Publications:

Kimmerer, W.J., E. Gartside, and J.J. Orsi. 1994. Predation by an introduced clam as the probable cause of substantial declines in zooplankton in San Francisco Bay. Marine Ecology-Progress Series 113:81-93.

Kimmerer, W.J. and J.J. Orsi. 1996. Causes of long-term declines in zooplankton in the San Francisco Bay estuary since 1987. pp. 403-424 in San Francisco Bay: The Ecosystem. J.T. Hollibaugh (ed.). AAAS, San Francisco.

Project Co-leader Steven Moore is an Associate Engineer with the San Francisco Bay Regional Water Quality Control Board. He received a Bachelor's degree in Biological Sciences and a Master's degree in Civil and Environmental Engineering from Stanford University. Prior to his current position with the Regional Board, Mr. Moore worked as a Senior Engineer with Montgomery Watson Consulting Engineers and as an Environmental Analyst at Earth Metrics.

Mr. Moore's regulatory experience includes wetlands permitting, watershed monitoring and assessment, NPDES permitting and compliance, total maximum daily load (TMDL) development and implementation, and toxic pollutant control. He is currently working on the development of a TMDL for nonindigenous species.

Mr. Moore will have primary responsibility for managing the analysis of the physical and chemical characteristics of ballast water, and the microbial/water quality analysis of ballast water.

James Orsi is a Senior Specialist with the California Department of Fish and Game. He has been Project Leader for the Neomysis/Zooplankton study since 1972 and has published several papers on nonindigenous zooplankton in the Bay/ Delta estuary. He is also co-editor of *California Fish and Game*.He and his laboratory staff will be available to assist with zooplankton identification.

Mary McGann is a Research Geologist at the U. S. Geological Survey. She has conducted several studies on foraminifers in San Francisco Bay, including an introduced Japanese foraminifer that has become common in San Francisco Bay and other estuaries on the Pacific Coast. Ms. McGann will identify the foraminifers collected from ballast sediments and ballast water.

Marjorie Wonham is a Ph. D. candidate in Biology at the University of Washington, where she is conducting research on nonindigenous species in the coastal waters of Washington state. Prior to enrolling at the University, Ms. Wonham directed a research project at the Smithsonian Environmental Research Center that involved sampling ballast water on commercial ships traveling from Europe to the United States. Ms. Wonham will serve as a technical consultant for the ballast water sampling program.

	Primary Area of Responsibility
Project Leaders:	
Andrew N. Cohen	Overall management of project Shipping data acquisition and analysis Ballast water sampling Larval culturing
Wim Kimmerer	Identification of zooplankton Larval culturing
Steven M. Moore	Water quality analysis
Collaborators:	
James J. Orsi	Identification of zooplankton
Mary McGann	Identification of foraminifera
Majorie Wonham	Technical assistance for ballast water sampling

References

Carlton, J. T. & J. B. Geller. 1993. Ecological roulette: the global transport of nonindigenous marine organisms. *Science* 261: 78-82.

Carlton, J. T., Reid, D. M. & H. van Leeuwen. 1995. *The Role of Shipping in the Introduction of Nonindigenous Aquatic Organisms into the Coastal Waters of the United States (other than the Great lakes) and an Analysis of Control Options*. US Coast Guard, Groton CT and US Department of Transportation, Washington DC.

Cohen, A.N. & J.T. Carlton. 1995. *Nonindigenous Species in a US Estuary: A Case Study of the Biological Invasions of the San Francisco Bay and Delta*. US Fish and Wildlife Service, Washington DC.

Cohen, A.N. & J.T. Carlton. 1997. Transoceanic transport mechanisms: the introduction of the Chinese mitten crab *Eriocheir sinensis* to California. *Pacific Science* 51(1): 1-11.

Cohen, A.N. & J.T. Carlton. 1998. Accelerating invasion rate in a highly invaded estuary. *Science* 279:555-58.

Cohen, A.N. 1998. *Ships' Ballast Water and the Introduction of Exotic Organisms into the San Francisco Estuary: Current Status of the Problem and Options for Management.* A report for CALFED, Sacramento.

Dodgshun, T. & S. Handley. 1997. *Sampling Ships' Ballast Water: a Practical Manual*. Cawthron Inst, Nelson, NZ.

Kimmerer, W.J., E. Gartside & J.J. Orsi. 1994. Predation by an introduced clam as the probable cause of substantial declines in zooplankton in San Francisco Bay. *Mar. Ecol. Prog. Ser.* 113:81-93.

Meng, L. & J. J. Orsi. 1991. Selective predation by larval striped bass on native and introduced copepods. *Trans. Amer. Fish. Soc.* 120: 187-192.

Oemke, D. & J. H. van Leeuwen. 1998. *Chemical and Physical Characteristics of Ballast Water: Implications for Treatment Processes and Sampling Methods*. CRC Reef Research Tech. Rep. No. 23, Townsville, Australia.

Orsi, J. J. 1995. Radical changes in the Estuary's zooplankton caused by introductions from ballast water. *IEP Newsletter* summer 1995: 16-17.

Strathmann, M. F. 1987. *Reproduction and Development of Marine Invertebrates of the Northern Pacific Coast: Data and Methods for the Study of Eggs, Embryos, and Larvae*. University of Washington Press, Seattle.

Sutton, C. A. , Murphy, K., Martin, R. B. & C. L. Hewitt. 1998. *A Review and Evaluation of Ballast Water Sampling Protocols*. CSIRO, Hobart, Tasmania.

Thompson, J. & S. Luoma. 1999. Food web and contaminant flow effects of an exotic bivalve in San Francisco Bay, California. Paper presented at the First National Conference on Marine Bioinvasions, January 24-27, 1999, Massachusetts Institute of Technology, Cambridge MA.

APPLICATION FOR FEDERAL ASSISTANCE

OMB Approval No. 0348-0043

2. DATE SUBMITTED	Applicant Identifier
April 16, 1999	
3. DATE RECEIVED BY STATE	State Application Identifier
4. DATE RECEIVED BY FEDERAL AGENCY	Federal Identifier

1. TYPE OF SUBMISSION:

Application	Preapplication
☐ Construction	☐ Construction
☒ Non-Construction	☐ Non-Construction

5. APPLICANT INFORMATION

Legal Name: San Francisco Estuary Institute

Organizational Unit:

Address *(give city, county, State, and zip code):* 1325 S.46th Street Contra Costa County Richmond, CA 94804

Name and telephone number of person to be contacted on matters involving this application *(give area code)*: MARGARET R. JOHNSTON 510 23109539

6. EMPLOYER IDENTIFICATION NUMBER *(EIN)*: 94-2951373

7. TYPE OF APPLICANT: *(enter appropriate letter in box)* ☐

A. State
B. County
C. Municipal
D. Township
E. Interstate
F. Intermunicipal
G. Special District
H. Independent School Dist.
I. State Controlled Institution of Higher Learning
J. Private University
K. Indian Tribe
L. Individual
M. Profit Organization
N. Other (Specify) Non-Profit Research

8. TYPE OF APPLICATION:

☒ New ☐ Continuation ☐ Revision

If Revision, enter appropriate letter(s) in box(es) ☐ ☐

A. Increase Award B. Decrease Award C. Increase Duration
D. Decrease Duration Other *(specify)*:

9. NAME OF FEDERAL AGENCY:

10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER: ☐☐-☐☐☐

TITLE:

11. DESCRIPTIVE TITLE OF APPLICANT'S PROJECT: Determining the Biological, Physical and Chemical Characteristics of Ballast Water Arriving in the SAn Francisco Bay/Delta Estuary

12. AREAS AFFECTED BY PROJECT *(Cities, Counties, States, etc.)*:

13. PROPOSED PROJECT		14. CONGRESSIONAL DISTRICTS OF:	
Start Date	Ending Date	a. Applicant	b. Project
10/99		7TH	7TH

15. ESTIMATED FUNDING:

a. Federal	$ 375,905.00
b. Applicant	$ .00
c. State	$ .00
d. Local	$ .00
e. Other	$ .00
f. Program Income	$ .00
g. TOTAL	$ 375,905.00

16. IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?

a. YES. THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON:

DATE _____

b. No. ☐ PROGRAM IS NOT COVERED BY E. O. 12372
☐ OR PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW

17. IS THE APPLICANT DELINQUENT ON ANY FEDERAL DEBT?

☐ Yes If "Yes," attach an explanation. ☒ No

18. TO THE BEST OF MY KNOWLEDGE AND BELIEF, ALL DATA IN THIS APPLICATION/PREAPPLICATION ARE TRUE AND CORRECT, THE DOCUMENT HAS BEEN DULY AUTHORIZED BY THE GOVERNING BODY OF THE APPLICANT AND THE APPLICANT WILL COMPLY WITH THE ATTACHED ASSURANCES IF THE ASSISTANCE IS AWARDED.

a. Type Name of Authorized Representative	b. Title	c. Telephone Number
Margaret R. Johnston	Executive Director	510 231-9539
d. Signature of Authorized Representative		**e. Date Signed**
Margaret R. Johnston		4/16/99

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Standard Form 424 (Rev. 7-97)
Prescribed by OMB Circular A-102

I -019950

I-019950

OMB Approval No. 0348-0044

BUDGET INFORMATION - Non-Construction Programs

SECTION A - BUDGET SUMMARY

Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1.		$	$	$ 375,905	$	$ 375,905
2.						
3.						
4.						
5. Totals		$	$	$	$	$

SECTION B - BUDGET CATEGORIES

6. Object Class Categories	GRANT PROGRAM, FUNCTION OR ACTIVITY (1)	(2)	(3)	(4)	Total (5)
a. Personnel	$ 153,334	$	$	$	$ 153,334
b. Fringe Benefits	29,056				29,056
c. Travel					
d. Equipment	25,000				25,000
e. Supplies					
f. Contractual	59,986				59,986
g. Construction					
h. Other	36,700				36,700
i. Total Direct Charges (sum of 6a-6h)					
j. Indirect Charges	71,829				71,829
k. TOTALS (sum of 6i and 6j)	$ 375,905	$	$	$	$ 375,905
7. Program Income	$	$	$	$	$

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Prescribed by OMB Circular A-102

I—019951

I-019951

SECTION C - NON-FEDERAL RESOURCES

(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e) TOTALS
8.	$	$	$	$
9.				
10.				
11.				
12. TOTAL (sum of lines 8 - 11)	$	$	$	$

SECTION D - FORCASTED CASH NEEDS

	Total for 1st Year	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
13. Federal	$ 208,003	$ 77,210	$ 45,710	$ 40,275	$ 44,808
14. NonFederal					
15. TOTAL (sum of lines 13 and 14)	208,003	77,210	45,710	40,275	44,808

SECTION E - BUDGET ESTIMATES OF FEDERAL FUNDS NEEDED FOR BALANCE OF THE PROJECT

(a) Grant Program	FUTURE FUNDING PERIODS (Years) (b) First	(c) Second	(d) Third	(e) Fourth
16.	$ 167,903	$	$	$
17.				
18.				
19.				
20. TOTAL (sum of lines 16-19)	$ 167,903	$	$	$

SECTION F - OTHER BUDGET INFORMATION

21. Direct Charges:	22. Indirect Charges:
304,076	71,829

23. Remarks:

I-019952

I-019952

STATE OF CALIFORNIA

NONDISCRIMINATION COMPLIANCE STATEMENT

STD. 19 (REV. 3-95) FMC

COMPANY NAME

SAN FRANCISCO ESTUARY INSTITUTE

The company named above (hereinafter referred to as "prospective contractor") hereby certifies, unless specifically exempted, compliance with Government Code Section 12990 (a-f) and California Code of Regulations, Title 2, Division 4, Chapter 5 in matters relating to reporting requirements and the development, implementation and maintenance of a Nondiscrimination Program. Prospective contractor agrees not to unlawfully discriminate, harass or allow harassment against any employee or applicant for employment because of sex, race, color, ancestry, religious creed, national origin, disability (including HIV and AIDS), medical condition (cancer), age, marital status, denial of family and medical care leave and denial of pregnancy disability leave.

CERTIFICATION

I, the official named below, hereby swear that I am duly authorized to legally bind the prospective contractor to the above described certification. I am fully aware that this certification, executed on the date and in the county below, is made under penalty of perjury under the laws of the State of California.

OFFICIAL'S NAME

Margaret R. Johnston

DATE EXECUTED

4/16/99

EXECUTED IN THE COUNTY OF

Contra Costa County

PROSPECTIVE CONTRACTOR'S SIGNATURE

PROSPECTIVE CONTRACTOR'S TITLE

Executive Director

PROSPECTIVE CONTRACTOR'S LEGAL BUSINESS NAME

San Francisco Estuary Institute

I —019953

I-019953

OMB Approval No. 0348-0040

ASSURANCES - NON-CONSTRUCTION PROGRAMS

PLEASE DO NOT RETURN YOUR COMPLETED FORM TO THE OFFICE OF MANAGEMENT AND BUDGET. SEND IT TO THE ADDRESS PROVIDED BY THE SPONSORING AGENCY.

NOTE: Certain of these assurances may not be applicable to your project or program. If you have questions, please contact the awarding agency. Further, certain Federal awarding agencies may require applicants to certify to additional assurances. If such is the case, you will be notified.

As the duly authorized representative of the applicant, I certify that the applicant:

1. Has the legal authority to apply for Federal assistance and the institutional, managerial and financial capability (including funds sufficient to pay the non-Federal share of project cost) to ensure proper planning, management and completion of the project described in this application.

2. Will give the awarding agency, the Comptroller General of the United States and, if appropriate, the State, through any authorized representative, access to and the right to examine all records, books, papers, or documents related to the award; and will establish a proper accounting system in accordance with generally accepted accounting standards or agency directives.

3. Will establish safeguards to prohibit employees from using their positions for a purpose that constitutes or presents the appearance of personal or organizational conflict of interest, or personal gain.

4. Will initiate and complete the work within the applicable time frame after receipt of approval of the awarding agency.

5. Will comply with the Intergovernmental Personnel Act of 1970 (42 U.S.C. §§4728-4763) relating to prescribed standards for merit systems for programs funded under one of the 19 statutes or regulations specified in Appendix A of OPM's Standards for a Merit System of Personnel Administration (5 C.F.R. 900, Subpart F).

6. Will comply with all Federal statutes relating to nondiscrimination. These include but are not limited to: (a) Title VI of the Civil Rights Act of 1964 (P.L. 88-352) which prohibits discrimination on the basis of race, color or national origin; (b) Title IX of the Education Amendments of 1972, as amended (20 U.S.C. §§1681-1683, and 1685-1686), which prohibits discrimination on the basis of sex; (c) Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. §794), which prohibits discrimination on the basis of handicaps; (d) the Age Discrimination Act of 1975, as amended (42 U.S.C. §§6101-6107), which prohibits discrimination on the basis of age; (e) the Drug Abuse Office and Treatment Act of 1972 (P.L. 92-255), as amended, relating to nondiscrimination on the basis of drug abuse; (f) the Comprehensive Alcohol Abuse and Alcoholism Prevention, Treatment and Rehabilitation Act of 1970 (P.L. 91-616), as amended, relating to nondiscrimination on the basis of alcohol abuse or alcoholism; (g) §§523 and 527 of the Public Health Service Act of 1912 (42 U.S.C. §§290 dd-3 and 290 ee 3), as amended, relating to confidentiality of alcohol and drug abuse patient records; (h) Title VIII of the Civil Rights Act of 1968 (42 U.S.C. §§3601 et seq.), as amended, relating to nondiscrimination in the sale, rental or financing of housing; (i) any other nondiscrimination provisions in the specific statute(s) under which application for Federal assistance is being made; and, (j) the requirements of any other nondiscrimination statute(s) which may apply to the application.

7. Will comply, or has already complied, with the requirements of Titles II and III of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (P.L. 91-646) which provide for fair and equitable treatment of persons displaced or whose property is acquired as a result of Federal or federally-assisted programs. These requirements apply to all interests in real property acquired for project purposes regardless of Federal participation in purchases.

8. Will comply, as applicable, with provisions of the Hatch Act (5 U.S.C. §§1501-1508 and 7324-7328) which limit the political activities of employees whose principal employment activities are funded in whole or in part with Federal funds.

9. Will comply, as applicable, with the provisions of the Davis-Bacon Act (40 U.S.C. §§276a to 276a-7), the Copeland Act (40 U.S.C. §276c and 18 U.S.C. §874), and the Contract Work Hours and Safety Standards Act (40 U.S.C. §§327-333), regarding labor standards for federally-assisted construction subagreements.

10. Will comply, if applicable, with flood insurance purchase requirements of Section 102(a) of the Flood Disaster Protection Act of 1973 (P.L. 93-234) which requires recipients in a special flood hazard area to participate in the program and to purchase flood insurance if the total cost of insurable construction and acquisition is $10,000 or more.

11. Will comply with environmental standards which may be prescribed pursuant to the following: (a) institution of environmental quality control measures under the National Environmental Policy Act of 1969 (P.L. 91-190) and Executive Order (EO) 11514; (b) notification of violating facilities pursuant to EO 11738; (c) protection of wetlands pursuant to EO 11990; (d) evaluation of flood hazards in floodplains in accordance with EO 11988; (e) assurance of project consistency with the approved State management program developed under the Coastal Zone Management Act of 1972 (16 U.S.C. §§1451 et seq.); (f) conformity of Federal actions to State (Clean Air) Implementation Plans under Section 176(c) of the Clean Air Act of 1955, as amended (42 U.S.C. §§7401 et seq.); (g) protection of underground sources of drinking water under the Safe Drinking Water Act of 1974, as amended (P.L. 93-523); and, (h) protection of endangered species under the Endangered Species Act of 1973, as amended (P.L. 93-205).

12. Will comply with the Wild and Scenic Rivers Act of 1968 (16 U.S.C. §§1271 et seq.) related to protecting components or potential components of the national wild and scenic rivers system.

13. Will assist the awarding agency in assuring compliance with Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. §470), EO 11593 (identification and protection of historic properties), and the Archaeological and Historic Preservation Act of 1974 (16 U.S.C. §§469a-1 et seq.).

14. Will comply with P.L. 93-348 regarding the protection of human subjects involved in research, development, and related activities supported by this award of assistance.

15. Will comply with the Laboratory Animal Welfare Act of 1966 (P.L. 89-544, as amended, 7 U.S.C. §§2131 et seq.) pertaining to the care, handling, and treatment of warm blooded animals held for research, teaching, or other activities supported by this award of assistance.

16. Will comply with the Lead-Based Paint Poisoning Prevention Act (42 U.S.C. §§4801 et seq.) which prohibits the use of lead-based paint in construction or rehabilitation of residence structures.

17. Will cause to be performed the required financial and compliance audits in accordance with the Single Audit Act Amendments of 1996 and OMB Circular No. A-133, "Audits of States, Local Governments, and Non-Profit Organizations."

18. Will comply with all applicable requirements of all other Federal laws, executive orders, regulations, and policies governing this program.

SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL	TITLE
[signature]	Executive Director
APPLICANT ORGANIZATION	**DATE SUBMITTED**
San Francisco Estuary Institute	April 16, 1999

99E-110

PSP Cover Sheet (Attach to the front of each proposal)

Proposal Title: Determining the Biological, Physical and Chemical Characteristics of Ballast Water Arriving in the San Francisco Bay/Delta Estuary

Applicant Name: Andrew N. Cohen, San Francisco Estuary Institute

Mailing Address: 1325 South 46th Street, Richmond, CA, 94804

Telephone: (510)231-9539

Fax: (510)231-9414

Email: acohen@sfei.org

Amount of funding requested: $ 375,905.00 for 2 years

Indicate the Topic for which you are applying (check only one box).

- ☐ Fish Passage/Fish Screens
- ☐ Habitat Restoration
- ☐ Local Watershed Stewardship
- ☐ Water Quality
- ☒ Introduced Species
- ☐ Fish Management/Hatchery
- ☐ Environmental Education

Does the proposal address a specified Focused Action? ____ yes x no

What county or counties is the project located in? Contra Costa

Indicate the geographic area of your proposal (check only one box):

- ☐ Sacramento River Mainstem
- ☐ Sacramento Trib: ____
- ☐ San Joaquin River Mainstem
- ☐ San Joaquin Trib: ____
- ☐ Delta: ____
- ☐ East Side Trib: ____
- ☐ Suisun Marsh and Bay
- ☐ North Bay/South Bay: ____
- ☐ Landscape (entire Bay-Delta watershed)
- ☒ Other: ____

Indicate the primary species which the proposal addresses (check all that apply):

- ☒ San Joaquin and East-side Delta tributaries fall-run chinook salmon
- ☒ Winter-run chinook salmon
- ☒ Late-fall run chinook salmon
- ☒ Delta smelt
- ☒ Splittail
- ☒ Green sturgeon
- ☒ Migratory birds
- ☒ Other: Any species may be affected.
- ☒ Spring-run chinook salmon
- ☒ Fall-run chinook salmon
- ☒ Longfin smelt
- ☒ Steelhead trout
- ☒ Striped bass
- ☒ All chinook species
- ☒ All anadromous salmonids

Specify the ERP strategic objective and target (s) that the project addresses. Include page numbers from January 1999 version of ERP Volume I and II:

Eliminate introductions of new species in ballast water, prevent invasion of zebra mussel, halt introduction of invasive aquatic plant (Vol. 1, pg. 420); Eliminate the dumping of organism-contaminated ballast water and ballast sediment (Vol. 1, pg. 464). Reduce/eliminate influx of non-native species in

Determining the Biological, Physical and Chemical Characteristics of Ballast Water Arriving in the San Francisco Bay/Delta Estuary

Project Leader:
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Co-Leaders:
Wim Kimmerer
Senior Research Scientist
Romberg Tiburon Center,
San Francisco State University

Steven M. Moore
Associate Engineer
California Regional Water Quality Control Board
San Francisco Bay Region

Collaborators:
James J. Orsi
Senior Specialist
Project Leader, Neomysis/Zooplankton Study
California Department of Fish and Game

Mary McGann
Research Geologist
U. S. Geological Survey

Marjorie Wonham
Ph. D. candidate, Department of Biology
University of Washington

Type of organization:
501(c)(3) Non-profit Research Institute
Tax ID #94-2951373